New Literature: Ph.D. Thesis

Economic Drama and the Environmental Stage

Formal Derivation of Algorithmic Tools for Environmental Analysis and Decision-Support from a Unified Epistemological Principle (in English with a Dutch summary: XX + 203 pp.)

by Reinout Heijungs*

In environmental policy, one is often confronted with the question which environmental problems are associated with which economic activity. The answer to this question is often unclear. On the one hand there is of course a limited knowledge of certain environmental issues. More fundamental, however, is the question who is þresponsibleþ, in a well-defined sense, for what. For instance, electric power plants emit carbon dioxide, but they do it because other industries and households exert a demand for electricity. Another example is the case that some countries are cutting down their rain forests to satisfy the import demands of other countries. A question is now: *who is polluting or depleting where and for whom?*

To answer this question, a number of tools for environmental decision-support have been developed, including life-cycle assessment, substance-flow analysis, environmental impact assessment, and risk assessment. Many of these tools have different economic entities (a product, a regional substance-flow, a factory, a use and emission pattern of a substance, etc.) as their object. It has proven to be difficult to reconcile all these different points of view on environmental problems and put them into a single perspective.

This study addresses two main questions:

1. **The attribution problem:** which environmental problems are to be attributed to which economic activity?
2. **The position problem:** what is the position of a number of the various tools for environmental decision-support?

Part 1: It does so by building a selected number of tools for environmental analysis and decision-support from unified principles. The principles are the elements that are first discussed: the epistemological basis of all further scientific analysis and synthesis is one of linear attribution. It is stated that current environmental problems are caused by current economic activities, and that certain formal requirements (such as 100%-additivity) lead directly to this linear attribution rule. It is important to realize that the attribution problem cannot be solved by experimental methods, and that the answers given by no means pretend to explain anything in terms of either natural science or social science. It is merely a mathematical structure that to some extent is based on a number of postulated properties.

Part 2 develops from the principle of linear attribution the concept of economic processes as activities that convert economic and environmental commodities into other economic and environmental commodities. The operating time of the economic process is a central element in this discussion: it determines how much þutilityþ is produced and how much environmental intervention is generated in doing so.

Another important step is the clustering of several economic processes into a larger economic process or system. In the end, two modes of analysis are developed from this consideration:

1. *commodity-flow accounting*, in which the operating times of all the economic processes within a certain region are set to a fixed and equal time period, e.g., one year;
2. *activity-level analysis*, in which the operating times of the processes within the cluster are determined by a specified external demand.

This crossroad of analytical thoughts leads to the derivation of the inventory analysis of the tools of life-cycle assessment and substance-flow analysis. Moreover, the relationships with a number of other tools, in particular environmental impact assessment and risk assessment, can be elucidated.

This brings us to a description of the exchange of matter between economy and environment, but not further. For a subsequent analysis of environmental consequences, the concept of environmental processes must be introduced:

In *one* respect, these are similar to economic processes. They also convert economic and environmental commodities into economic and environmental commodities.

In *another* respect, however, they are quite different: the operating times are rigid.

While we can say that we need, say, 5 seconds of a steel factory to produce a certain product, we cannot do anything similar for environmental processes. We therefore must take these processes into account for an infinitely long time-period, meanwhile ensuring that we do not underestimate the transient environmental problems.

To this end, **Part 3** proposes to use the time-integrated presence or absence of environmental commodities as a starting point. Consideration of such quantities brings in environmental processes like degradation, intermedia transport, and formation, or, in short, the fate of environmental commodities. It is argued that degradable chemicals and renewable resources can indeed be adequately treated using time-integration, but that persistent chemicals and non-renewable resources fall outside this treatment. This leads to a distinction between transient stressors (degradable or renewable

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environmental commodities for which the integral over infinite time converges) and permanent stressors (persistent or non-renewable environmental commodities for which the asymptotical presence or absence is used as a measure). The stressors are those entities that exert the impacts on the environment: it is not the release of a certain chemical to a certain compartment which is problematic, but the fact that this results in the (temporary) presence of a certain chemical in a certain compartment, while the chemical may have been transformed into a different one, and the compartment in which it is found may have changed following a transport process.

The **starting point** for the attribution of impacts to stressors is the design of a standard list of impact categories. Although it is difficult to establish a definite list, the current ideas within life-cycle impact assessment are followed as a best state-of-the-art. The quantitative measures for indicating the contribution to these impact categories are critically reviewed, however. It appears that, while much of the inventory work resembles the results for established lca-work, the impact analysis deviates in many respects:

1. In the *first* place, it is the consequent inclusion of fate which make a difference.
2. In the *second* place, the average attribution rule proposed from the epistemological principles designed to answer the attribution problem, do not appear to be in line with the majority of present approaches to life-cycle impact assessment. Neither are they in line with the established methods for substance-flow analysis, partly because these established approaches have not been designed for answering the attribution problem.

A quite new attribution system of environmental impacts is therefore proposed. Unfortunately, this proposal requires information that lies beyond the knowledge that can be accessed, because the chosen epistemological principles are not sufficient to construct a complete procedure.

The **last element** of Part 3 is the normative interpretation of environmental impacts in terms of the environmental problem that is perceived by individuals or by society. Once more, the aggregation rule follows from the epistemological principles but needs information that might be difficult to obtain.

Part 4 gives answers to the two main questions of this thesis. The attribution problem is solved by summarizing the formal unified structure of a number of tools for environmental analysis and decision-support. The position problem is answered by a comparative analysis of the different tools.

The study ends with a number of further questions and some more philosophical reflections.

The specific question addressed in this study was the attribution problem, which was introduced as the question of which environmental problems are to be attributed to which economic activities.

It is shown that the question of attribution is only one of the questions that can be posed in connection with environmental analysis and decision-support, and that other questions, in particular with respect to planning and scenario analysis, require distinctive epistemological principles, thereby leading to different implementations of the same tools of life-cycle assessment, substance-flow analysis, etc.

Moreover, the chosen epistemology is indeed a chosen one, and certainly not the only one. We therefore end up with a rather confusing situation: the question of the environmental friendliness of a certain economic activity cannot be unambiguously answered, as there are many competing truths. All of these truths correspond to a certain interpretation of the question: "*Should the activity be seen in a life-cycle perspective, in a substance-flow perspective, or as an independent entity? Are we considering an additional activity, or an average existing one?*"

Despite these open questions, the study can be seen as developing a foundation for a number of tools for environmental analysis and decision-support, a foundation which leaves minimum scope for ambiguities, inconsistencies, and arbitrariness.

Dr. Reinout Heijungs
Center of Environmental Science (CML)
Leiden University
Section Substances & Products
P. O. Box 9518
NL-2300 RA Leiden
The Netherlands

Announcement of a New Report

The Centre of Environmental Science of Leiden University (CML) announces a recent publication in the field of LCA impact assessment of input-related categories: natural resources and land use. The report was commissioned by the **Japan Environmental Management Association for Industry** (JEMAI), and is written by REINOUT HEIJUNGS, JEROEN GUINÉE and GJALT HUPPES.
It contains a survey and analysis of existing and proposed methods, covering a substantial part of the developments during the nineties. The three main areas of discussion are extraction of abiotic resources, extraction of biotic resources, and land use. It concludes with recommendations for use and further research.
The report may be ordered through the library of CML, telephone +31-71-5277485, fax +31-5275587, postal address P.O. Box 9518, 2300 RA Leiden, The Netherlands. Please indicate the report number: 138. Costs are Dfl 20, excluding mailing costs.